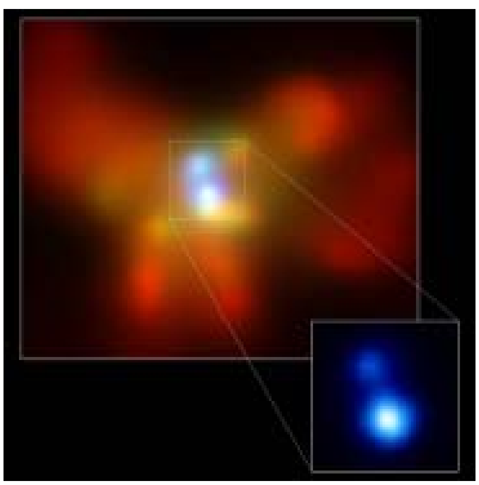
LISA

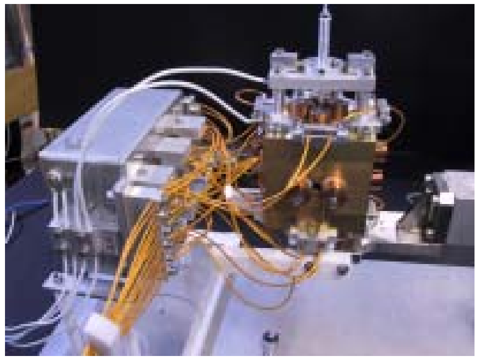
Mapping the Low Frequency Gravitational Wave Sky

LISA Science

Gravity dominates the structure of the Universe, compacting matter into planets, stars, galaxies, clusters of galaxies. It produces ultra-compact objects such as white dwarf stars, neutron stars and black holes that are the ultimate fate of matter. When gravity draws these compact objects close together and they merge, gravity and energy reach their extremes in the Universe today. Gravitational waves - ripples in space-time - are produced. These extremely violent events may be the final merger of giant black holes at the centers of merging galaxies, they may be intermediate-sized black holes coming together as the giants grow, they may be the swallowing of a dead star by a massive black hole in the center of a galaxy, or they may be collapsed stars within our own Milky Way, locked in a fatal duet.



The Laser Interferometer Space Antenna (LISA) will detect gravitational waves from throughout the Universe. Those waves carry information about their source, virtually unaffected by intervening matter. With these observations, we can: probe the formation of structure in the early Universe, study the creation and growth of supermassive black holes, map space and time around supermassive black holes, explore the history of galaxy mergers, catalog compact objects throughout our galaxy, and possibly see the first moments after the Big Bang. Gravitational waves carry unique information about the most extraordinary astrophysical settings and the most extreme physics in the Universe.



LISA Technology

LISA relies on three key technologies: reduction of disturbances on the masses, an interferometry measurement system, and system verification technologies.

Disturbances on the masses can mask the small apparent motions caused by gravitational waves. LISA is adapting the technologies and flight heritage of ultra-sensitive accelerometers, "drag-free" satellites and microthrusters to reduce or eliminate unwanted forces. LISA requires improvements in the performance demonstrated by ultra-sensitive accelerometers and drag-free satellites (i.e., spacecraft controlled to follow enclosed reference mass) over the last 30 years. Low thrust, low noise, proportional thrusters are important for quiet drag-free operation. Microthrusters based on liquid metal ion propulsion promise to satisfy LISA requirements, and have a flight heritage as spacecraft charge control devices.

LISA's interferometry measurement system uses established techniques for measuring distances with great precision. The reference design calls for 1 W solid-state lasers, laser frequency-stabilization, an ultra-stable 30 cm telescope, and a precision phase measurement system.

LISA's very low disturbance requirements and its extent when deployed preclude full system verification on the ground. In recognition, a combination of laboratory measurement, integrated modeling and ground simulation equipment are being developed to ensure that the final flight system performs as required. Further, confidence in the design of the disturbance reduction system will be enhanced by a flight demonstration of the technology.

http://lisa.nasa.gov

Mission Baseline

- *Spacecraft (each of three): 402 kg, 432 W*
- *Launch Vehicle: single Delta IV*
- *Orbits: heliocentric, 1 AU*
- *Lifetime: Five-year operational/ ten-year extended*
- *Instrument complement: Two gravitational sensors with free-falling mass and electrostatic sensing, 30 cm telescope, optical bench, 1 W laser*
- *Instrument performance: 10^{-23} strain sensitivity 3 to 10 mHz*

The LISA Mission

LISA is a joint European Space Agency (ESA)-NASA project to design, build and operate the first space-based, gravitational-wave observatory. The instrument monitors changes in the separations of reference masses in three spacecraft 5 million kilometers apart. The three spacecraft orbit the Sun in a triangular formation following 20° behind the Earth. Changes in separation of the reference masses smaller than the diameter of an atom are measured using laser interferometry. The reference masses are freely-falling, and sheltered, but untouched, by their enclosing spacecraft which follows them in their orbit.